ON *ANODONTA CYGNÆA* (LINN.) CONTRASTED WITH *ANODONTA ANATINA* (LINN.); AND ON *PSEUDANODONTA ROTHOMAGENSIS*, LOCARD.

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Read 8th December, 1916.

PLATE XI.

The questioned relationship of *Anodonta anatina* to *A. cygnæa* is the reason the following work has been undertaken.

The intention in the first instance was to make a more exhaustive investigation, but the War has prevented the obtaining of specimens from a number of important places in this country as well as from the Continent. A comparison of the British species with the Continental forms of *Anodonta* would have conveyed a more comprehensive grasp of the subject, but since some considerable time must elapse before this is possible it is felt desirable to give the result of the research so far, incomplete though it may be.

It is further hoped that the ecological portion will induce other conchologists to record their experiences of similar areas.

Thanks are acknowledged to the following for their kindly help in specimens or notes: B. B. Woodward, A. S. Kennard, Dr. F. Haas, J. R. B. Masefield, F. Booth, W. Blake, B. R. Lucas, P. T. Deakin, and others.

Anodonta cygnæa (Linn.).

Shell.—In the following description Jeffreys has, to a great extent, been followed.

Shell oblong, slightly ventricose, thin, moderately glossy, yellowish green or brown, transversely and irregularly grooved by the lines of growth, and wrinkled in the same direction on the posterior and ventral sides; periostracum thin; umbones placed at a distance of nearly one-fourth from the anterior extremity; ligament rather long and strong, partly concealed within the overlapping edges of the dorsal margin or hinge-line, which is straight; anterior side not gaping, rounded, and somewhat abruptly sloping ventrally; posterior side gradually sloping and compressed above, produced into a rounded wedge-like extremity and slightly gaping; ventral margin slightly curved; inside pearly white and sometimes iridescent; hinge slight, having a rather sharp ridge-like plate on the posterior side in each valve; muscular and pallial scars very slight and often indistinct.

Animal.—The specimen described (Pl. XI, Fig. 1) was taken from Bracebridge Pool, Sutton Coldfield. It measures 100 mm. antero-posteriorly by 55 mm. dorso-ventrally, is somewhat flattened dorsally, being nearly parallel to the long axis of the animal, is curved anteriorly, slightly curved ventrally, and more or less bluntly triangular posteriorly.

The colour of the proximal part of the foot is white or greyish white, sometimes tinged with orange, whilst the distal part is

usually of an orange shade, becoming more pronounced towards the keel. The mantle is generally of an orange shade, varying in intensity and occasionally spreading to the dorsal surface as well as colouring the labial palps and adductor muscles.

The mantle is thin and bordered by the circumpallial muscles which form a shallow band (Fig. 1, *C.M.*). At the posterior end the mantle encloses the siphonal apertures, the inhalent (*In.A.*) being larger than the exhalent one (*Ex.A.*). The mantle fringe of the former has from fifty to seventy tentacles on each side.

On the removal of the shell the exposed terminal or lateral parts of the pallial and pedal muscles present the following characters:—

The anterior adductor (*A.A.*) is curved anteriorly, flattened posteriorly, and has the ventral larger than the dorsal part.

The posterior adductor (*P.A.*) is posteriorly deeply and broadly convex; anteriorly it is slightly concave.

The anterior retractor pedis (*R.P.A.*) is irregularly shaped, with the ventro-anterior edge resting on the centre of the posterior side of the anterior adductor.

The anterior protractor pedis (*P.P.A.*) is round, and situated some distance from the ventro-posterior edge of the anterior adductor.

The posterior retractor pedis (*R.P.P.*) is of an oblong shape and has its posterior edge in contact with the dorsal side of the posterior adductor.

A certain latitude must be allowed in the description of the shape of the muscles as they all, more or less, vary, and this particularly applies to the protractor and retractor muscles. In these the chief point to be remembered is their relative position to the adductor muscles.

Anodonta anatina (Linn.).

Shell.—In describing this species Jeffreys has again been closely followed.

Shell oval, rather ventricose, moderately thick, glossy, olive green or brown with darker transverse bands denoting the lines of growth, and irregularly wrinkled in the same direction; periostracum thick; umbones placed at a distance of about one-third from the anterior end; ligament comparatively short and prominent; dorsal margin or hinge-line ascending for some distance posteriorly; anterior side rounded and gaping ventrally, with an oblique slope towards the ventral edge; posterior side compressed above, curved, and abruptly sloping to a wedge-like extremity; ventral margin curved; hinge and ridge-like plate the same as in *A. cygnæa*; inside the shell is thick, pearly white and iridescent, while the muscular and pallial impressions are deep and quite distinct.

Animal.—The specimen described (Pl. XI, Fig. 2) was taken from Longmore Pool, Sutton Coldfield.

The dorsal edge is curved, but it ascends from the umbonal region for some distance towards the posterior end. The anterior edge is curved, whilst the posterior is very bluntly triangular with its apical

portion lying ventro-posteriorly. The ventral edge has a distinct symmetrical curve.

The colour of the foot is white or greyish white, often tinged with yellow, becoming deeper towards the keel, where at times orange replaces the yellow. The mantle has generally a yellow shade, occasionally passing to a light orange. Some pools yield specimens having no orange or yellow colour about them.

The mantle is bordered by a deep band of circumpallial muscles (Fig. 2, *C.M.*), which are deeper at the anterior and posterior ends, more particularly the latter, where they are developed and form the siphonal chambers. These are large and occupy the whole of the posterior area, the inhalent (*In.A.*) being much larger than the exhalent one (*Ex.A.*). The former is bordered by a tentacular fringe, each side having from 120 to 200 small tentacles.

The exposed terminal parts of the muscles present the following features:—

The anterior adductor (*A.A.*) is large with the anterior part curved and the posterior portion irregular, particularly the ventro-posterior part.

The posterior adductor (*P.A.*) is also large, inclined to be more or less spherical but slightly prolonged ventro-posteriorly and flattened antero-dorsally.

The anterior retractor pedis (*R.P.A.*) has a somewhat triangular shape with the base close to the posterior edge of the anterior adductor and the apex lying in a dorso-posterior direction.

The anterior protractor pedis (*P.P.A.*) presents an irregularly shaped and relatively large surface and lies near the ventro-posterior edge of the anterior adductor.

The posterior retractor pedis (*R.P.P.*) is bluntly triangular, with the base resting upon the dorsal edge of the posterior adductor.

As in *A. cygnæa*, too much importance must not be attached to the description of the shape of the retractors and protractors but rather their relative position to the adductor muscles.

The two species contrasted.

Shell.—The shell is relatively larger in *A. cygnæa*, but is more oval, ventricose, and thicker in *A. anatina*; the periostracum is usually thicker and of a darker colour—an olive green or brown—in *anatina*; the umbonal region is more central in *anatina*; the ligament is longer and nearly hidden by the dorsal growth of the shell in *cygnæa*, in *anatina* it is exposed and prominent; dorsally *cygnæa* is straight, whereas *anatina* is curved and from the umbonal region ascending for some distance posteriorly; the ventral part of the anterior edge is gaping in *anatina* and usually closed in *cygnæa*, but if gaping then only slightly; the ventral margin of *anatina* is a little more curved; posteriorly both species are wedge-shaped, but the extremity is more pointed and situated more dorsally in *cygnæa*; the muscular and pallial scars are far more distinct in *anatina*, whilst in *cygnæa* they are often difficult to trace completely.

Dorso-ventral sections of the shell show *cygnæa* to be of a uniform

thickness, whilst in *anatina* it greatly increases towards the ventral edge. This condition is also noticeable in young specimens of *anatina*.

Animal.—In *cygnæa* there is a comparatively straight and horizontal (to the long axis of the animal) dorsal edge, whereas in *anatina* from the umbonal region it is slightly curved and ascending for some distance posteriorly. Anteriorly *cygnæa* is slightly more curved than *anatina*. Ventrally the edge is more curved in *anatina* than in *cygnæa*, whilst posteriorly both species are triangular, being sharper in *cygnæa* than *anatina*.

The siphonal apertures are comparatively larger in *anatina* than in *cygnæa*, but in both the inhalent is larger than the exhalent aperture. Further in *cygnæa* they are situated near the centre of the posterior border, and, lying in an inclined plane, have a slightly dorsal aspect. In *anatina* they are more vertical, occupy a greater surface, and have a more ventral position.

The inhalent aperture is bordered by a tentacular fringe. The number of tentacular processes is less for *cygnæa* than *anatina*, being always under 100 on each side for *cygnæa* and more than 100 for *anatina*, approximately 50 to 70 for *cygnæa* and from 120 to 200 for *anatina*. Though the processes are fewer in number in *cygnæa* they are larger in size.

The colour of the mantle and foot of *cygnæa* is usually of an orange shade, whilst that of *anatina* is, when coloured, of a yellow shade. The intensity of the colouring is invariably greater in *cygnæa* than *anatina*.

The question of coloration deserves closer attention from the point of view of periodicity as well as distribution.

In *cygnæa* the labial palps, that is those portions below the line of attachment to the body of the animal, are not proportionately so large in area as in *anatina*, and in *anatina* the distal part is pointed and more produced rearwardly than in *cygnæa*.

The gills in *cygnæa* ascend gradually in a dorso-anterior direction, whilst in *anatina* they ascend much more rapidly and the dorso-anterior portion lies more dorsally than in *cygnæa*.

The circumpallial muscles of *anatina* form a considerably deeper band than that possessed by *cygnæa*.

The exposed terminal parts of the muscles of the right side, viz. :—

The anterior adductor muscle is curved on the anterior edge in both species. Dorsally *cygnæa* has a sharper curve than *anatina*. Ventrally *cygnæa* has a rounder edge than *anatina*. Posteriorly *cygnæa* has a more uneven edge than *anatina*. Further the muscle is relatively larger in *anatina* than in *cygnæa*, but in both species it has a tendency to vary in shape.

The posterior adductor muscle in *cygnæa* is broadly crescent-shaped, whilst in *anatina* it is somewhat spherical. In *anatina* it is comparatively very large, and is situated slightly more dorsally than in *cygnæa*. This muscle, like the anterior adductor, has a disposition to vary in shape, though in a lesser degree.

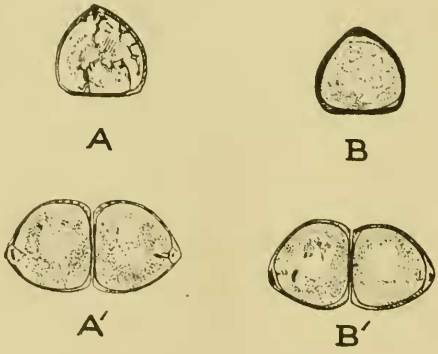
The anterior retractor pedis muscle is of an irregular shape in

cygnæa and triangular in *anatina*, with the base near the anterior adductor, but in *cygnæa* the apex lies in a dorsal plane, and the base is a little farther away from the adductor than in the other species.

The anterior protractor pedis muscle is larger in *anatina* than in *cygnæa*, and in the latter it is relatively farther away from the anterior adductor. Moreover, in *cygnæa* it lies in a direction ventro-posteriorly to the anterior adductor, whereas in *anatina* it is posterior to that muscle.

The posterior retractor pedis is of an oblong shape in *cygnæa* and triangular in *anatina*. In *anatina* it is close to the dorsal surface of the posterior adductor, and in *cygnæa* is a little farther away from the muscle with its dorsal edge nearly parallel to the long axis of the animal.

In describing and comparing the shape of the exposed parts of the muscles as viewed from the right side of the animal just after the removal of the shell, it must be borne in mind that there is often considerable variation when comparing one specimen with another of the same species, and further, the shape on the right side of the animal may be, and often is, different to that on the left side. Since this variation even extends to a comparison of the median sections it consequently does not follow that the spreading out of the muscles near the lateral extremities altogether explains the difference in the external shape. Great as the variation may be it is nevertheless confined within certain limits, and it is quite possible to determine the species by an examination of the exposed terminal parts of the muscles alone.



Embryos.—If the embryos when passed into the marsupium are examined under a low magnification it will be observed that there is a difference between those of *cygnæa* and *anatina* which is constant, namely, that the apical region or growing part is pointed in *cygnæa* (*A*, *A′*) and blunt in *anatina* (*B*, *B′*). Usually the sides are more curved in *anatina*, making quite a shoulder in the upper part, but this character is not quite so constant. The base or hinge region is the same in both species.

General Conclusions.—The examination of a large number of *A. cygnæa* has shown that the shells are fairly constant in form in any one area, whilst they have been found to present certain differences when contrasted with those of other areas. It has also been stated that there is a degree of variation in the external characters of the animals themselves as far as the muscular parts are concerned; there may further be a slighter variation in the position and shape of the siphonal parts and the number of tentacular processes, yet a critical examination bears conviction that they are true *cygnæa*.

A. anatina shows much more marked variation, although the type shell is invariably present and generally in considerable numbers. It is when the so-called doubtful specimens are scrutinized that the difficulties become apparent, and it is really astonishing what curious shapes the shell assumes in some areas. Out of one pool may be taken very many specimens all differing from each other: this, it must be admitted, more particularly obtains where *cygnæa* and *anatina* are found in the same water, though it may be only a coincidence and arise from some other cause. However, an examination of the external characters of the animals proves them to be variations of the type form of *anatina*, because of the predominance of the characters of this species. It is not to be presumed that hybridization does not occur, but at present no direct evidence is available of it taking place.

The conclusion at this stage points to the fact that *A. cygnæa* and *A. anatina* are distinct species, that hybridization is extremely doubtful, that *anatina* has a great tendency to vary, and in this respect it would seem that this species has arrived at a phase known to occur in other branches of Mollusca.

Ecological Study of the Anodons of Sutton Park Area.

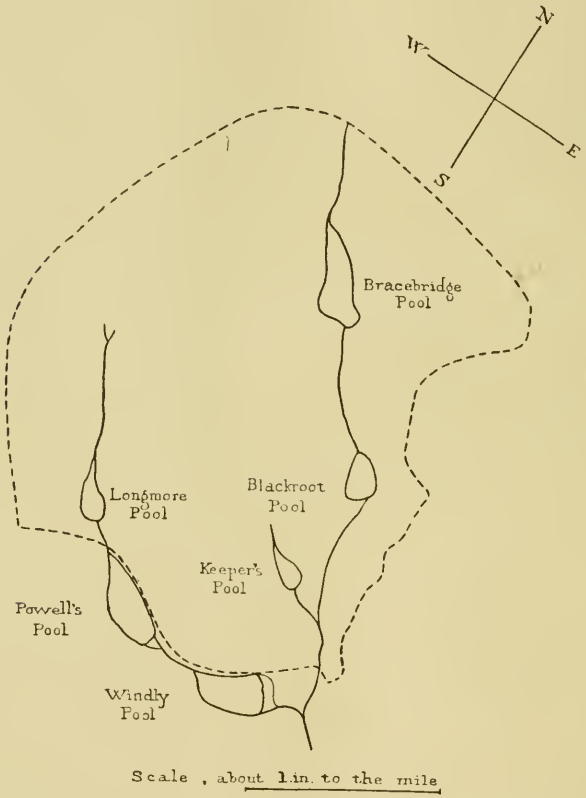
The bulk of the material used in this investigation has been obtained from the vicinity of Sutton Coldfield and particularly Sutton Park. The latter, a large enclosed area, retains to a certain extent some of its natural features, and consists of heath and bog-land interspersed with elevated tracts clothed with oaks, hollies, pines, etc. The drainage is effected by two small streams running in a south-easterly direction, uniting outside the park, and thence flowing into the River Tame. From the beginning of the fifteenth to the end of the eighteenth century these streams were dammed up at various places to form pools, chiefly for industrial purposes. Some have since been filled in, but six situated within or on the border of the park area remain, viz.:—

Bracebridge Pool, made 1420.
Blackroot Pool, made 1757.
Keeper's Pool, made between 1420 and 1462.
Longmore Pool, made 1735.
Powell's Pool, made some time during the eighteenth century.
Windly Pool, made during Norman times.

The accompanying sketch shows their respective positions.

Bracebridge Pool contains *A. cygnæa*. It is present in great numbers, and its shape is very constant. The specimen described in this work may be taken as typical of not only the pool but of the species. *A. anatina* is absent.

Blackroot Pool contains both *A. cygnæa* and *A. anatina*. *A. cygnæa* is normal, but *anatina* possesses a number of specimens which vary from the type. Only a limited number from this pool has been examined.



In Keeper's Pool neither *A. cygnæa* nor *A. anatina* is found.

Longmore Pool contains only *A. anatina*. A very large number of specimens from this water has been examined. The type is quite prevalent, but there is also to be found a number varying more or less from it. Some viewed laterally are almost globose, and it is possible to find every grade of shape between the latter and the type.

Powell's Pool contains both *A. cygnæa* and *A. anatina*.

Windly Pool also contains both, and a great many have been examined. *A. cygnæa* is fairly constant in its shape, but in *anatina*,

though the type is common, there is a very large number of specimens which vary from the type. There is also a number of specimens which at first were considered of a doubtful nature. Were they hybrids or extreme variations of *anatina*? As previously explained they proved on a critical examination to possess such characters as undoubtedly determine them to be varieties of *anatina*, and as such they are accepted. It should further be noted that this tendency to vary is more pronounced in this pool than in Longmore Pool.

It will thus be observed that the first pool on each stream contains only one species, i.e. *A. cygnæa* in Bracebridge Pool and *A. anatina* in Longmore Pool, whilst the next pool in succession on each stream contains both. It is only when *A. anatina* is present that the tendency to vary prevails. The evidently interesting point is that Bracebridge Pool, which was made nearly 500 years ago, does not possess *A. anatina* but contains *A. cygnæa* in large numbers, and Longmore Pool, formed 180 years ago, does not contain *A. cygnæa* but has *anatina* in profusion, a considerable number of which varies from the type.

Since the above was written a few dead shells of *A. anatina* have been taken near the upper end of Bracebridge Pool. This is explained by the fact that a few years ago a local naturalist transferred some *Unio pictorum* and *A. anatina* from a pool which was being filled up and so introduced *A. anatina*. It must also be stated that a few dead shells of *A. cygnæa* have been likewise taken from the upper end of Longmore Pool, and there are strong grounds for believing an attempt has recently been made to introduce this species into this pool as well.

Pseudanodonta rothomagensis, Locard.

Shell.—Shell sub-oval, slightly compressed, moderately thick, glossy, dark olive or brownish-green colour, transversely grooved by lines of growth, and wrinkled in the same direction on the anterior and posterior sides; epidermis of medium thickness; umbones nodulous, placed at a distance of nearly one-fourth from the anterior end; ligament long and prominent; dorsal side from umbonal region curved anteriorly, also curved and ascending posteriorly; anterior side curved and sloping ventrally, widely gaping, slight oblique compression posteriorly inclined as from the umbonal region; posterior side compressed above, wedge shaped with the extremity situated somewhat ventrally; inside pearly white with the central part tinged a salmon cream colour, iridescent; hinge slight with a prominent ridge-like plate as in *Anodonta cygnæa*; muscular and pallial scars distinct.

Animal.—The specimen described was taken from the River Teme, near Knightswick, by Mr. W. H. Foxall, to whom we wish to express our thanks for this and other specimens he has allowed us to examine.

The animal examined measures 77 mm. by 43 mm. The dorsal portion is roughly triangular, with the apex about 10 mm. nearer the

posterior than the anterior end. The anterior part is rounded, whilst the posterior end is bluntly triangular.

In colour the mantle is slightly a greyish-white, whilst the anterior part has a sulphur tinge and the posterior part near the margin an orange one. The foot is white.

The mantle is bordered by the band of circumpallial muscles (Pl. XI, Fig. 3, *C.M.*), which are deeper at the posterior than along the anterior and ventral edges.

The inhalent aperture (*In.A.*) is nearly the same size as the exhalent one (*Ex.A.*). Along each side of them the inner longitudinal fold of the mantle is produced in a pronounced manner, and when required the free edges come together and close the apertures. On the inner surface of it, bordering the inhalent aperture, is a number of tentacular processes, about fifty on each side, arranged in four irregular rows. The row nearest the outer edge possesses the smallest in size but the largest in number. In the next two rows the processes are larger—the ones in the rear row alternating with those in front. In the last row are to be found the largest in size but fewest in number.

The exposed terminal parts of the muscles exhibit the following features:—

The anterior adductor muscle (*A.A.*) situated in the dorso-anterior part of the animal is nearly twice the size measured dorso-ventrally by antero-posteriorly, with rounded margins except on the posterior side, where the dorsal part curves inwardly and in the recess of which closely lies the anterior retractor pedis muscle. Below this is a slight contraction, and to the rear of the posterior part is situated the anterior protractor pedis muscle.

The posterior adductor muscle (*P.A.*) is large and somewhat round in shape, slightly projecting at the antero-ventral part and flattened at the antero-dorsal edge. On the latter rest the retractor pedis posterior muscles.

The anterior retractor pedis muscle (*R.P.A.*) is triangular in shape and situated close to the dorso-posterior edge of the anterior adductor.

The anterior protractor pedis muscle (*P.P.A.*) is of an irregular shape and lies a short way from the ventro-posterior margin of the anterior adductor.

The posterior retractor pedis muscle (*R.P.P.*) is of a triangular shape, with the base resting on the posterior adductor.

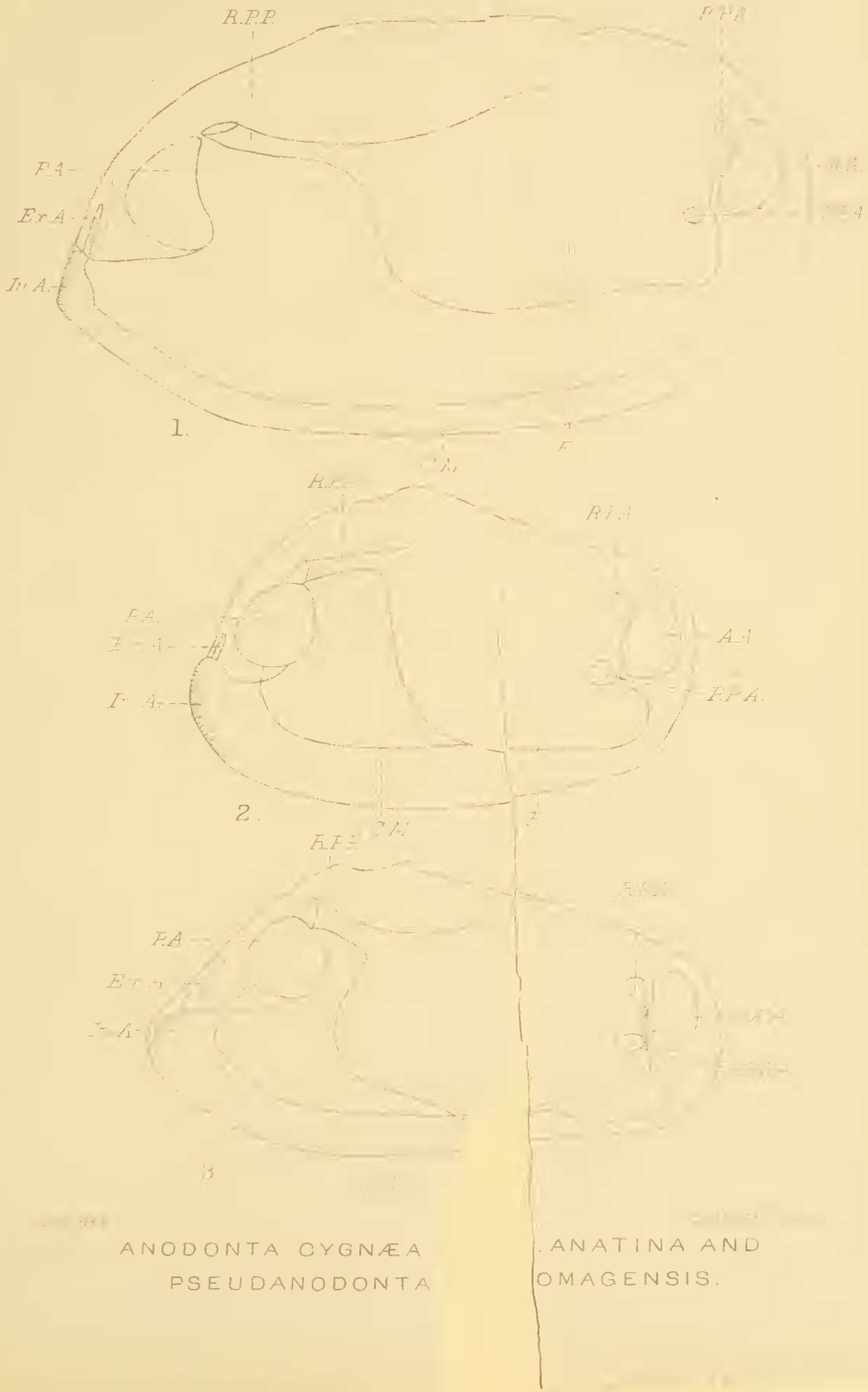
EXPLANATION OF PLATE XI.

FIG.

1. *Anodonta cygnæa* (Linn.).
2. *A. anatina* (Linn.).
3. *Pseudanodonta rothomagensis*, Locard.

All of the natural size.

A.A. anterior adductor muscle.
C.M. circumpallial muscle.
Ex.A. exhalent aperture.
F. foot.
In.A. inhalent aperture.
P.A. posterior adductor muscle.
P.P.A. anterior protractor pedis muscle.
R.P.A. anterior retractor pedis muscle.
R.P.P. posterior retractor pedis muscle.



ANODONTA CYGNÆA ANATINA AND
PSEUDANODONTA OMAGENSIS.